911 – What's your Emergency?

IPPC = Intergovernmental Panel on Climate Change; RCP = Representative Concentration Pathways ENSO = El Niño-Southern Oscillation AMOC = Atlantic Meridional Overturning Circulation

TIPPING POINTS

A Climate Emergency

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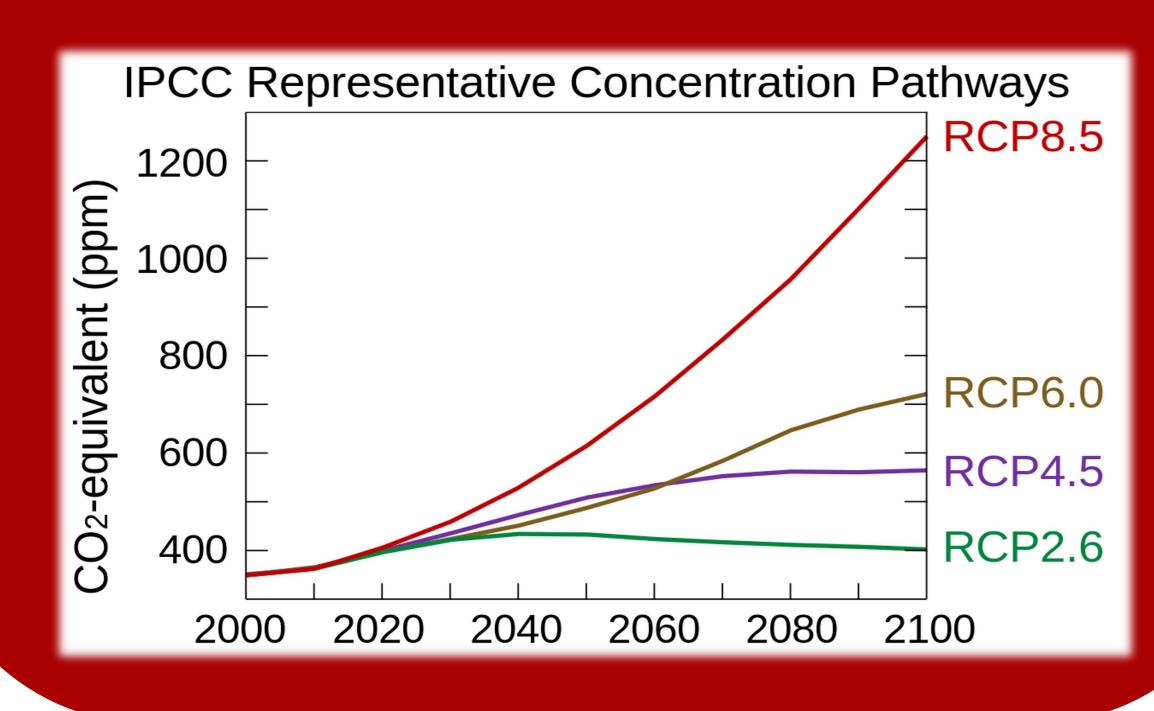


- Impact on climate systems, ecosystems, social systems, economic systems, ...
- overall stability of the earth system



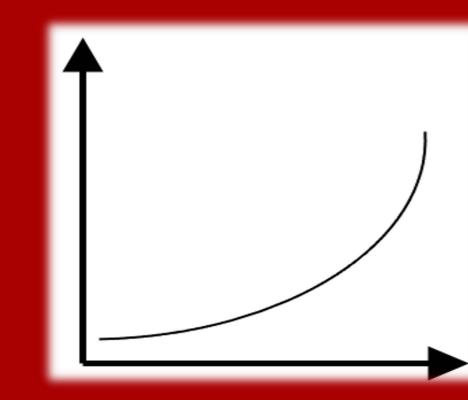
WHEN?

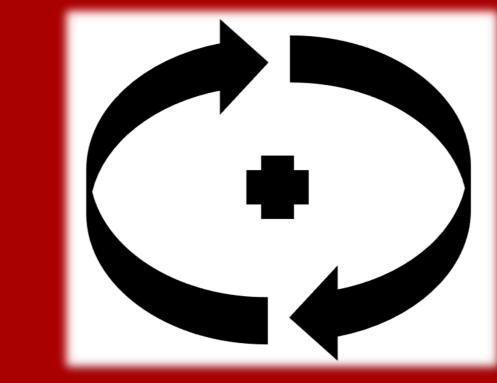
- Antropogenic climate change
- increasing CO₂-concentration and global warming increases probability to reach tipping points
- Uncertainty about exact thresholds
- Abprubt changes (few years)
- Gradual transitions (millenia)
- Paris agreement 2015 set the goal to keep the long-term mean temperature rise below 2°C above pre-industrial level
 - Tipping points of Cryosphere and other systems could poissbily reach their critical threshold even in case of RCP2.6 (RCP2.6 is the only trajectory compatible with the Paris agreement)

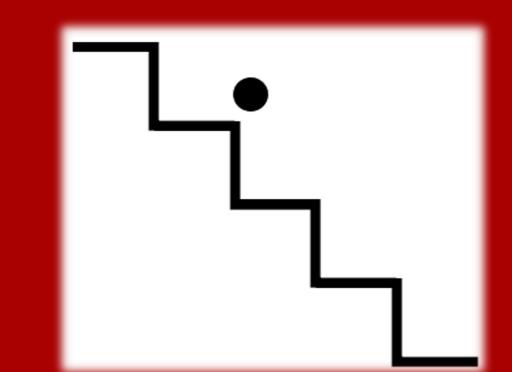


WHAT?

Tipping points describe the critical threshold at which a small perturbation can ,tip' a system into a qualitatively new state







- Irreversible change
- Positive feedbackloops
- Domino-like chain reaction
- Non-linear behaviour
- Interactions might produce a global tipping point
- Risk of "Hothouse Earth" where conditions for humans get undesirable - Steffen et al. 2018

WHERE?

Tipping elements are large-scale components of the earth system that interact globally



Cryosphere

- Loss of Arctic sea ice
- Loss of Greenland ice sheet
- Thawing permafrost
- Loss of west and east Antarctic ice sheet



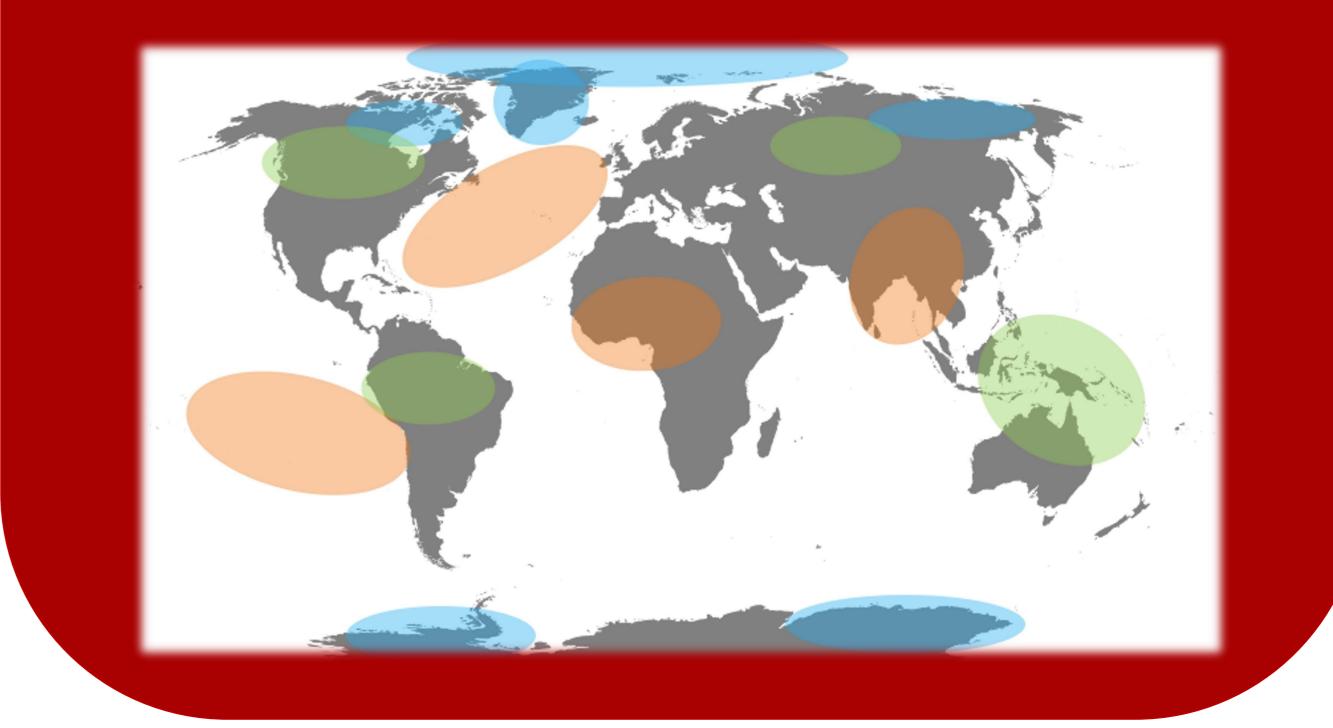
Circulation patterns

- Shift of west African monsoon
- Chaotic multistability of Asian monsoon
- Change in **ENSO** amplitude or frequency
- Destabilization of AMOC



Biosphere components

- Loss of boreal forests
- Loss of Amazonas rainforest
- Loss of tropical coral reefs



- Armstrong McKay, D.; Staal, A.; Abrams, J.; Winkelmann, R.; Sakschewski, B.; Loriani, S.; Fetzer, I.; Cornell, S.; Rockström, J.; Lenton, T. (2022): Exceeding 1.5°C global warming could trigger multiple climate tipping points. In: Science, Vol. 377, Issue. 6611. Lenton, T.; Held, H.; Kriegler, E.; Hall, J.; Lucht, W.; Rahmsdorf, S.; Schellenhuber,, H. (2008): Tipping elements in the Earth´climate system. In: Proceedings of the national Academy of Science, Vol. 105, No. 6, pp. 1786-1793.
- Lenton, T.; Rockström, J.; Gaffney, O.; Rahmsdorf, S.; Richardson, K.; Steffen, W.; Schellenhuber, H. (2019): Climate tipping points too risky to bet against. In: Nature, Vol. 575, pp. 592-595.

Wunderling, N.; Donges, J.; Kurths, J.; Winkelmann, R. (2021): Interacting tipping elements increase risk of climate domino effects under global warming. In: Earth System Dynamics, Vol. 12, pp. 601-619.

- Lenton, T.; Armstrong McKay, D.; Loriani, S.; Abrams, S.; Lade, S.; Donges, J.; Milkoreit, M.; Powell, T.; Smith, S.; Zimm, C.; Buxton, J.; Bailey, E.; Laybourn, L.; Ghadiali, A.; Dyke, J. (2023): The Global Tipping Points Report 2023. Exeter. Potsdam Institute for Climate Impact Research (n.d.): Kipppunkte im Klimasystem. Eine kurze Übersicht. Potsdam.
- Steffen, W.; Rockström, J.; Richardson, K.; Lenton, T.; Folke, C.; Liverman, D.; Summerhayes, C.; Barnosky, A.; Cornell, S.; Crucifix, M.; Dongers, J.; Fetzer, I.; Lade, S.; Schaffer, M.; Winkelmann, R.; Schellenhuber, H. (2018): Trajectories of the Earth System in the Anthropocene. In: Proceedings of the National Academy of Sciences, Vol. 115, No. 33, pp. 8252-8259. Umweltbundesamt für Mensch und Umwelt (2008): Kipp-Punkte im Klimasystem. Welche Gefharen drohen? Dessau.
- Img. 1 Planet Earth: NASA (2015): Earth Western Hemisphere transparent background https://nl.wikipedia.org/wiki/Bestand: Earth_Western_Hemisphere_transparent_background.png
- Img. 2 RCP trajectories: Efbrazil (2020): All forcing agents' atmospheric CO2-equivalent concentrations from the IPCC AR5 report

Img. 7 World map: Adapted from vemaps (n.d.): Grey Map of the World with Antarctica https://vemaps.com/world/wrld-14

https://de.wikipedia.org/wiki/Repräsentativer_Konzentrationspfad#/media/Datei:All_forcing_agents_CO2_equivalent_concentration.svg Img. 3 Domino chain: Dmitriy83 (2019): Domino schwarz auf weißem Hintergrund https://www.istockphoto.com/de/foto/domino-schwarz-auf-weißem-hintergrund-drop-domino-effekt-hobbies-undunterhaltung-gm1097715920-294787069?phrase=domino%2Beffect&searchscope=image%2Cfilm

Img. 4 Cryosphere: Ai Graphic (n.d.): Eisberg im das Ozean ai generiert Kostenloses Foto Eisberg Fotos auf Lager von Vecteezy

Img. 5 Circulation patterns: Pixabay (n.d.): Foto Von Brown Bare Tree Auf Brown Surface Während Des Tages https://www.pexels.com/de-de/foto/foto-von-brown-bare-tree-auf-brown-surface-Img. 6 Bisophere components: David Riaño Cortés (n.d.): Regenwald Umgeben Von Nebel https://www.pexels.com/de-de/foto/regenwald-umgeben-von-nebel-975771/